Report of the Experts Committee

on

ECONOMY IN THE USE OF CEMENT IN BUILDING CONSTRUCTION

NATIONAL BUILDINGS ORGANISATION

The Ministry of Works, Housing and Supply, Government of India appointed a Committee in July, 1956, consisting of the following members to examine the question of economy in the use of Cement:—

Sardar Sarup Singh, Director, National Building Organisation (Chairman).

Shri J. M. Rijhwani, Chief Engineer, Central P.W.D.

Shri H. R. Hay, Building Materials Adviser, Government of India. (Member until Nov. '56).

Shri S. K. Joglekar, Chief Architect, Central P.W.D.

Shri C. B. Patel, Housing Adviser, Government of India.

Co-opted members:—

Shri L. P. Bhargava, Member, Central Water and Power Commission.

Shri B. C. Ganguli, Joint Director, Civil Engineering Rly. Board.

Col. H. C. Vij, Deputy Director (Designs), E-in-C's Branch, Army Headquarters.

Shri M. S. Bhatia, Superintending Surveyor of Works, Central P.W.D. (deputised for the Chief Engineer).

Shri K. Rama Varman, Joint Director (Designs); and

Shri G. L. Bhandari, Officer on Special Duty, from the National Buildings Organisation assisted the Committee.

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ERRATA

Page 1.

Insert as paragraph No. 2 for the Introduction:

"A Committee was constituted by the Ministry of Works, Housing and Supply, Government of India, in July, 1956, to examine the question of economy in the use of Cement in building construction. The names of members of the Committee are given on the pre-page".

Page 2.

Foot note, 3rd line:

Read 'low', *For* 'lose'.

Page 6.

2nd para, 6th line:

Read 'Y inches per hundred inches'. *For* 'Y inches hundred inches'.

Page 11. *Table VI*

Serial No. 6, Item 2:

Read 'cavity wall', *For* 'cavite wall'.

Serial No. 4(v), Item 6: *Read* 'A'.

Serial No. 4 (vi and viii), Item 6:

Read 'B or C' *For* 'A,B & C.D'.

Foot note No. 2, 2nd line:

Read '28' *For* '20'.

Page 12.

Title for 5th para:

Read 'Use of Cement in other parts of structures'. *For* 'Use of Cement in other structures'.

INTRODUCTION

In view of the acute shortage of cement,* the Government of India, Ministry of Works, Housing and Supply have given serious consideration to the ways and means to curtail as far as possible the use of cement. As all development involves construction, the demand for cement is likely to press heavily on the available supplies and it is essential that economy in the use of cement should be affected where possible.

This report gives the recommendations of the Committee regarding substitution of cement by lime in mortars; adoption of alternate specifications for buildings to reduce the consumption of cement. These recommendations are based on available knowledge on the subject and are subject to review as a result of research and further investigations in connection with the strength of lime-mortars, composite cement-lime, and of masonry construction, etc., which have been assigned to the Central Building Research Institute, Roorkee, for investigations. The Committee recommends that Organisations connected with the building constructions both in the public and private sectors should make it obligatory to adopt these recommendations, subject to the availability of the right quality of materials.

Some of the recommendations like omission of cement plaster and avoidance of the use of cement in pavements are of interim nature as dictated by present shortage of cement and these may remain applicable so long as cement in our country in adequate quantities is not available.

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*Appendix I.

(Source: United Nations Reports)

MATERIAL FOR BUILDING MORTARS

At present, the most commonly used composition for masonry mortar is cement-sand. Alternative compositions which may be used are lime-sand, lime-surkhi, lime-cinder, lime-surkhi-sand, lime-cinder-sand, and lime-cement-sand.

Mud and gypsum for building mortars are not considered suitable; as mud mortar is not suitable for large undertakings in urban areas and gypsum mortars are yet to be developed.

The following specifications are recommended for the materials to be used in the alternative mortars:

Lime:—Lime may be hydraulic, semi-hydraulic or non-hydraulic and shall conform to Indian Standards' specifications for building limes:

Hydraulic lime	Class A
Semi-hydraulic lime	Class B
Non-hydraulic lime	Class C

Various tests that are to be carried out on limes before they are used on works should also conform to the Indian Standard Specifications.

Hydraulic lime has the property of hardening under water, the quicker the set the greater the hydraulicity. Non-hydraulic or fat lime have no real set in water but dissolves slowly in pure water when water is frequently changed.

Lime which is used in cement-lime mortar shall be high calcium quick lime or semi-hydraulic quick-lime, Class B or C, which shall slake readily when brought into contact with water so as to form putty free from a large residue of un-slakable material.

Hydraulic limes and magnesia limes shall not be used for cement-lime mortars.

Calcium quick-lime for use in lime mortars shall be run to putty and stored for at least 3 days. It shall then be mixed with sand, surkhi or cinders in specified proportions on a clean platform or in a mechanical mixture and then stored in a compact pile for not less than 4 hours or more than 48 hours before use.

For preparing composite cement-lime-sand mortars cement shall be added in specified proportions to ready-mixed lime-sand mortar just before use. Only such quantity of composite mortar shall be prepared as can be used up within 2 hours of mixing the cement.

Sand:—Sand to be used shall be inert and free from deleterious materials like acid, alkali, animal or vegetable organic matter. Coarse sand is preferable to mud sand in high strength mortars even though such mortars are likely to become harsh in a lean mix. Fine sand mixed mortar is more workable but reduces strength and leads to greater shrinkage.

For use in lime mortars fineness modulus of sand shall be above 1.9 and ninety per cent. of the fractions in a sieve analysis of the sample shall be retained on B.S. 60 (I.S. 25) sieve and shall pass B.S. 30 (I.S. 50) sieve. All fractions shall pass B.S. 10 (I.S. 170) sieve and shall be retained on B.S. 100 (I.S. 15) sieve.

Surkhi and cinders:—Both surkhi and cinders are pozzolanic* in action when used in conjuction with semi-hydraulic and non-hydraulic limes and make the resulting mortar harden more quickly. Surkhi is an artificial pozzolana. In the ordinary practice it is obtained from grinding the burnt bricks.

The soil for brick manufacture has to be loamy in character in order to avoid high shrinkage and consequent cracking during the process of burning. Hence it is rich in non-pozzolanic constituents and therefore the soil that is suitable for the manufacture of bricks is not necessarily the best for a good pozzolanic surkhi.

The puzzolanic activity of surkhi is mainly dependent on the fine fractions, consisting of secondary clay minerals and on the presence of silica and alumina, in such a condition, combined or free that reaction with lime proceeds with adequate speed. Strength test is the most satisfactory practical test. The rate of strength development of pozzolanas in lime mortars is influenced considerably by the fineness of grinding. The effect of fine grinding is more marked at short ages than at long ages.

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*Pozzolana may be defined as a siliceous material which though not cementitous in itself contains constituents which at an ordinary temperature will combine with lime in the presence of water to form compounds which have a lose solubility and possess cementing properties.

Surkhi should, therefore, be manufactured from clayey soils and should have such a fineness as will make it pass through a sieve of 8 meshes to the inch with at least 50 per cent. of it passing through a sieve of 16 meshes to the inch. Further the soluble salt content (sulphates) should not exceed 2 per cent by weight.

Cinders or furnace ashes have varying properties and little control exists over their quality. Cinders to be used shall be clean and ground in a mill and screened through a sieve containing at least 8 meshes to the inch. The stipulations regarding fineness given in the case of surkhi apply to cinders as well. The possibility of the presence of soluble sulphates and excessive unburnt carbon precludes the use of cinders in mortars in very wet situations.

PROPERTIES REQUIRED OF BUILDING MORTARS

Mortar plays an important role in building constructions. Its main function is to join together single units into a mass of masonry capable of bearing the loads imposed and withstanding the effects of weather. The important properties required in a good building mortar are:

(i) It should have easy *workability* thus reducing labour in application and ensuring proper filling of joints and spreading;

(ii) it should *stiffen* quickly to ensure a reasonable speed in construction and should develop adequate *strength* in compression, tension and bond;

(iii) it should *adhere* well to the bricks to prevent penetration of moisture;

(iv) it should be *durable* and should not affect the durability of other building materials or the building as a whole.

Workability:—Good workability needs (a) good water retentivity against suction and evaporation and (b) good trowelling properties. If the mortar loses water to the brick too rapidly, it stiffens quickly and intimate contact with the brick is vitiated (adherence is only in spots). In such cases the initial bond is poor and it is further reduced by volume changes in hardened mortar through successive wetting and drying. Workability exists in a mix in which the viscosity of the metrix is such as to allow distortion without segregation. A lean cement-mortar with coarse sand which is usually unworkable cannot be made workable by addition of water as this would only lead to segregation. Good water retentivity and plasticity impart better trowelling properties as the mortars spread better under the trowel, and fill up the joints.

Stiffening and Hardening:—While the rate of early hardening in mortar should be rapid enough to allow a normal rate of brick laying, it should be such that the plastic properties are retained till the actual shrinkage of the mortar is completed, thus diminishing the danger of cracks and opening of joints.

Strength:—Compressive strength in building mortars is of comparatively lesser importance. Even a mortar of low compressive strength of 100 pounds per sq. inch can bear the weight of several storeys of wall super-imposed on it. Tests on brick pillars, indicate that for each class of brick there is an optimum mix of mortar which gives the best results and a richer mix has hardly any advantage (Figures 1 and 2). For instance, brick pillars built in 1:1:6 cement lime and sand mortar used with bricks of less than 3,000 lbs. sq. inch compressive strength were found to have 96 per cent of the compressive strength of pillars built in 1:3 cement sand mortar, though the crushing strength of the former mortar was only about 60 per cent. of the latter.

Adhesive strength:—A good mortar should not only possess good tensile strength but also good adhesive strength. It is the bonding efficiency, i.e., the ratio of adhesive strength to the tensile strength of mortar which is an important factor for consideration.

(Note.—A high water-retaining and low volume change mortar ensures better bond. Good bonding capacity is dependant on the general adaptibility of the mortar as it enables the mortar to adhere uniformally and completely at all points. Poor bonding results in separation cracks between brick and mortar and is largely responsible for the penetration of moisture through walls.)

Durability:—Under persistantly damp conditions soluble sulphates from bricks come in contact with mortar and a chemical reaction between the sulphates and the mortar takes place. This is accompanied by marked change in volumes which may cause the mortar to crumble and brickwork to expand. Dense strong mortars are attacked slowly by sulphates but are not immune. For most normal brick work in super-structure, the question of sulphates needs no special consideration. There are however cases where high resistance to sulphates attack is essential. This may occur when the sub-soil water is high and contains considerable quantity of soluble sulphates. In such cases mortars containing high alumina cement instead of portland cement is suitable. Lime should not be used with high alumina cement but to reduce the strength of the mortar and the rate of hardening ground chalk, lime stone dust, or even surkhi can be used.

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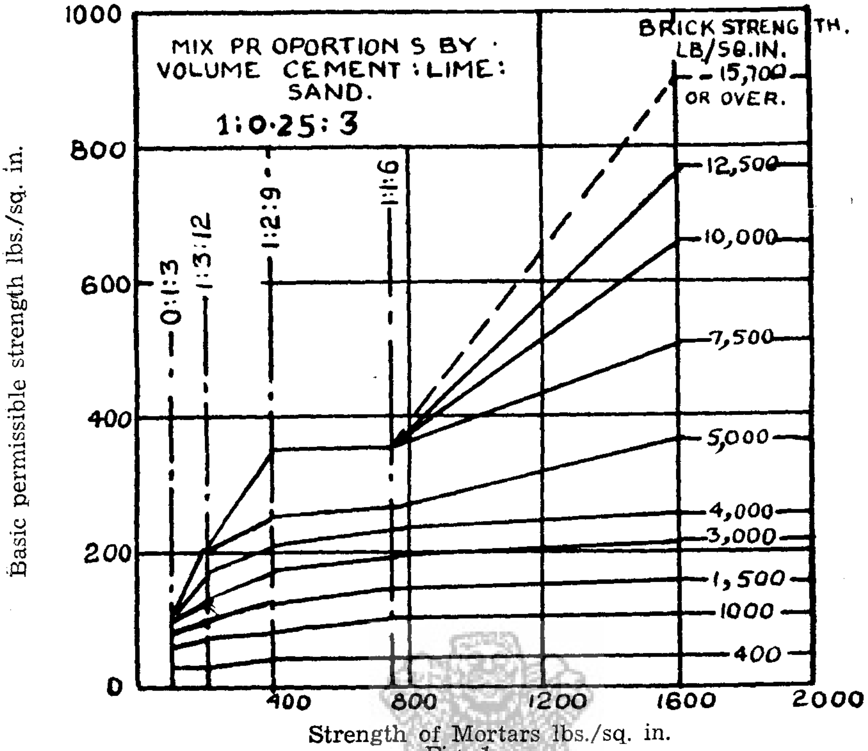

Fig. 1

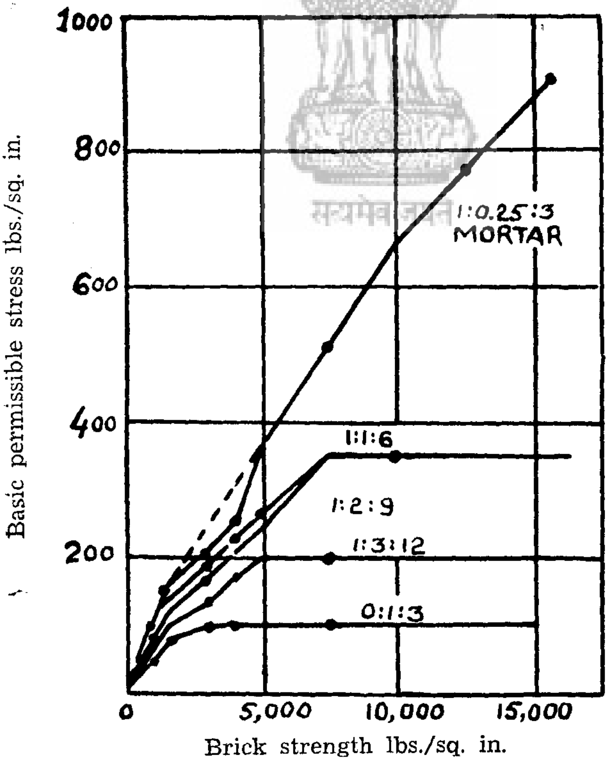

Fig. 2

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Results of test on brick pillars conducted at the Building Research Station, Watford, U. K.

CHARACTERISTICS OF CEMENT AND LIME MORTARS

Stiffening and Hardening.—Stiffening of mortar immediately is due to the loss of water through suction or evaporation. The development of the early strength of mortars is a continuation of the stiffening process. Mortars made of fat lime have no set and the hardening is due to slow carbonation. Addition of cement to lime mortars increases their hardening rate as shown in the following table:

TABLE I

Rate of hardening as indicated by Vicat tests

Mortar composition Cement : Lime : Sand (Proportions by volume of the same material)	Rate of hardening. (as measured by penetration in millimeters in 30 secs.)
0 : 1 : 3	22·7
1 : 3 : 12	3·5
1 : 2 : 9	2·5
1 : 1 : 6	1·0
1 : 0 : 3	0·8

(Extracted from Masonry Mortar Bulletin No. 321 National Lime Association, Washington—D.C.).

Extensibility.—Extensibility is defined as the maximum linear deformation that a hardened mortar may undergo before it fails in tension. It may be expressed in inches per hundred inches. The significance of this property is in its relation to the magnitude of volume changes subsequent to hardening. If the hardening motar shrinks X inches per hundred inches and has an extensibility of Y inches hundred inches its factor of safety in this respect is Y/X. The safety factor of unity or more is a desirable condition. The table below gives the factors of safety of different mortars at three months age as determined in some tests carried out in the U.S.A.

TABLE II

Extensibilities and factors of safety of mortars, Age 3 months—Average of 3 tests.

Mortar composition Cement : Lime : Sand (by volume)	Extensibility (inches per 100 inches)	Maximum shrinkage subsequent to hardening	Factors of safety (Col. 2/Col. 3)
0 : 1 : 3	0·031	0·0007	4·43
1 : 3 : 12	0·025	0·010	2·50
1 : 2 : 9	0·030	0·026	1·16
1 : 1 : 6	0·028	0·038	0·74
1 : 0 : 3	0·026	0·084	0·31

Tensile and Adhesive Strength.—The following table gives the tensile and adhesive strength of certain mortars after 28 days of curing. It also shows the bonding efficiency of the mortars *i.e.,* the ratio of adhesive strengh to tensile strength.

TABLE III

Serial No.	Mortar	Mix proportions	Nature of sand	Tensile strength lbs./sq. inch (28 days)	Adhesive strength lbs./sq. in. (28 days)	Percentage Bonding efficiency
1	Lime-sand	1 : 2	Fine	88·5	10·37	12
2	Lime-sand	1 : 3	Fine	83·0	4·67	6
3	do.	1 : 2	Course	62·4	15·65	25
4	do.	1 : 3	do.	46·9	6·75	14
5	Lime-Surkhi	1 : 2	..	75·4	25·28	33
6	do	1 : 3	..	49·52	24·06	48
7	Lime-Cinder	1 : 2	..	99·25	24·28	24
8	Do.	1 : 3	..	103·3	26·85	25
9	Cement-Sand	1 : 5	Fine	160·25	32·75	20
10	do.	1 : 7	do.	101·25	19·56	19
11	do	1 : 5	Course	172·4	27·28	16
12	do.	1 : 7	do.	134·1	17·96	13
13	Lime-Surkhi-Sand	1 : 1 : 1	Not specified.	79·25	35·46	45
14	Lime-Cinder-Sand	1 : 1 : 1	do.	83·3	13·3	15

(Extracted from 'Characteristics of Mortars' by Mehra & Chadda).

A study of tables I, II & III shows that—

(a) Lime-sand mortars are slow in stiffening and hardening but the rate of stiffening and hardening can be increased by addition of even a small percentage of cement to allow a normal rate of brick-laying.

(b) Lime-sand and composite cement-lime sand mortars have factors of safety of "Extensibility" of more than unity whereas the cement sand mortars of 1:3 has a factor of safety of only 0.31. Mortars richer in lime are, therefore, comparatively less liable to shrinkage cracks after hardening.

(c) Lime and sand mortars using fine sand have a low bonding efficiency which is considerably increased by the use of coarse sand. The use of surkhi and cinder in place of sand with lime increases both the tensile and adhesive strengths and results in high bonding efficiency. The use of sand in part replacement of surkhi to cut down cost (use of 1:1:1 lime-surkhi-sand mortar instead of 1:2 lime-surkhi mortar) does not adversely affect the tensile and adhesive strengths and the bonding efficiency. It actually shows an improvement. Use of sand in part replacement of cinder (1:1:1 lime-cinder-sand as compared with 1:2 lime-cinder) reduces the adhesive strength and bonding efficiency. Cement and sand mortars develop much higher tensile strength but their bonding efficiency is considerably lower than that of the lime-surkhi and lime-cinder mortars. Apart from the above, the Portland cement mortars increase only slightly in strength over a period of years.

An increase of 40 per cent over 28 days strength has been observed. The corresponding increase in the case of lime mortars (laboratory specimens) has been as much as 5 times while stored in air. It may be noted that the strengths of all the types of mortars depend on conditions of curing to a large extent.

MORTARS FOR DIFFERENT USES

An examination of the suitability of different mortars for different situations such as foundation concrete masonry in foundation and in super-structure, internal and external plastering, terraces and floors results in following recommendations:

Foundation concrete.—In places where good quality of lime to I.S.I. specifications is available and surkhi or cinders are also available cement can be entirely eliminated in foundation concrete except in particular areas where the soil contains excessive soluble salts or in areas with high-sub-soil water-table. The mortars recommended to be used for concrete are shown in Table IV. In the case of framed structures cement concrete is essential for foundations but economy in cement can be effected by designing the reinforced concrete foundations to the minimum requirements after carrying out more systematic investigations into the bearing capacity of the soil.

Masonry in foundation and super-structure in unframed and framed buildings.—The mortars suitable for masonry in foundation and super-structure are indicated in Tables V and VI. These tables contain a large number of alternatives using local materials namely, surkhi, cinder, hydraulic or non-hydraulic lime and sand. Except in places where neither hydraulic lime nor surkhi or cinders are available or in places where high early strength is required it should not be necessary to use appreciable quantities of cement for this part of construction.

The loading given in Table VI are to be used with a slenderness ratio of 1.0 and suitable reduction factors should be applied where the slenderness ratio exceeds 1.0. A chart showing the reduction factors and a note on how to determine the slenderness ratio are given in Appendix II

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TABLE IV

MORTARS FOR FOUNDATION CONCRETE

Serial No.	Situation	Type of mortar (all proportions by volume)	I. S.I. Grading of lime	Remarks
1	Dry Sub-grade, with sub-soil water-level never within 8′-0″ of the foundation level.	(*i*) 1 lime, 2 sand. (*ii*) 1 lime, 1 surkhi and 1 sand. (*iii*) 1 lime, 2 surkhi. (*iv*) 1 cement, 3 lime and 12 sand.	A. B, C or A B or C or A B or C.	Normally suitable for buildings not more than three storeys high. The quantity of mortar to be used will depend on the grade of aggregate.
2	Moist sub-grade with high sub-soil water usually 8′-0″ or less below foundation level.	1:4 or 1:3 (Cement and sand mortar.)		The corresponding concrete mix will be 1:4:8 or 1:3:6

TABLE V

MORTARS FOR MASONRY IN FOUNDATION AND PLINTH

Serial No.	Loading condition	Moist sub-grade with sub-soil water less than 8′-0″ below foundation level with high percentage of soluble sulphate	Moist sub-grade as in (2) with little or no soluble sulphates	Dry sub-grade with sub-soil water never within 8′-0″ of foundation level	I.S.I. Grading of lime
1		2	3	4	5
1	Heavy and medium loading (4 tons per sq. ft. and above)	1 cement : 3 sand (use of high alumina cement and puzzolanic cement is recommended)	1 cement, 1 lime and 6 sand.	1 cement, 1 lime and 6 sand.	B or C
2	Lighter loading (less than 4 tons per sq. ft.)	(a) Below ground level 1 cement 3 sand (high alumina cement and puzzolanic cement is preferred.) (b) In plinth. 1 cement, 1 lime and 6 sand.	1 cement 1 lime and 6 sand.	(*i*) 1 lime, 2 sand. (*ii*) 1 lime, 1 surkhi and 1 sand. (*iii*) 1 lime, 2 surkhi. (*iv*) 1 cement, 3 lime and 12 sand	A B, C or A B, C or A B or C.

Table VI
MORTARS FOR MASONRY IN SUPERSTRUCTURE IN UNFRAMED AND FRAMED BUILDINGS

Serial No. 1	Situation 2	Special conditions 3	Type of masonry unit 4	Type of mortar (proportion by volume) 5	I.S.I. Grading 6	Remarks 7
1	Load-bearing walls.	Very heavy loading (8-10 tons per sq. ft.)	Brick of crushing strength of not less than 1500 lbs. per sq. inch.	1 cement, 1 lime & 6 sand.	B or C	
2	do.	Arch-work.	Dense lime-stone, granite etc.	1 cement, 3 sand.	..	
3	do.	Heavy loading (6-8 tons per sq. ft.)	Brick or stone with crushing - strength 1000-1500 lbs. per sq. inch.	1 cement, 2 lime and 9 sand.	B or C	
4	do.	Medium loading (4-6 tons per sq. ft.)	do.	(*i*) 1 lime: 1 sand : 1 surkhi (*ii*) 1 lime: 1 sand : 1 cinder. (*iii*) 1 lime : 2 surkhi (*iv*) 1 lime : 2 cinder.	A,B or C	Tests should be carried out to determine whether 1:3:12 cement, lime and sand mortar could give adequate strength for this purpose.
				(*v*) 1 lime : 2 sand (*vi*) 1 cement : 2 lime and 9 sand. (*vii*) 1 cement 3 lime and 12 sand.'	A B & CD	
5	do.	Light loading below 4 tons per sq. ft.	Brick.	All lime mortars included under serial No. 4 for 'medium loading can be used.		
6	Cavite walls.	Light loading below 4 tons per sq. ft.	Brick.	1 cement, 1 lime and 6 sand	B or C.	
7	Reinforced brick work .		do.	1 cement, 3 sand with 10 per cent addition of class 'C' lime for better workability.		Addition of lime is approved.
8	Half-brick or brick-on-edge parapet walls.		Brick . .	1 cement, 1 lime 6 sand	B or C	
9	Non-load bearing partitions.		High weight concrete wood wool slab, hollow blocks.	1 lime, 3 sand . .	A or B	

NOTE. 1 :—All loadings given in this table are for a slenderness ratio of 1·0. Reduction factors as given in Appendix II are to be applied for slenderness ratio exceeding unity.

2 :—Lime mortars should be prepared and tested before specifying suitable proportions for important works. The proportions should be so adjusted that after 20 days curing in moist air, the mortar shall have a minimum tensile strenght of 80 per lbs. sq. inch. A bonding efficiency of 20 per cent is desirable.

External and Internal Plastering:—A list of alternative specifications suitable for plastering with materials usually available in various localities is given in Table VII. This table gives the specifications for single coat work which is used in most buildings. In the case of external plastering in two coats the same mortar mix as recommended for single coat work should be used in both the coats. For internal plastering the following practices are recommended.

(i) When lime mortar is used in the second coat over lime mortar or a cement-lime mortar first coat, the mix recommended for lime mortar in one coat plaster will apply.

(ii) Where plastering is done in three coats, the smoothening or finishing coat may be applied on a one-coat or on a two-coat depending on the degree of evenness required. The smoothening or finishing coat may be in lime and sand mix 1:1.

(iii) The sand used for plastering in all cases shall be well graded from coarse to fine.

USE OF CEMENT IN TERRACES OF FLAT-ROOFS

The use of cement for water proofing terraces should be avoided altogether except for pointing or grouting of tiles etc., except in certain very wet areas like Bombay. The prevalent specifications in the Housing Board, Central P.W.D., and the Provincial P.W.D. in Bombay are $1\frac{1}{2}$ inch cement concrete laid in panels and slabs over a layer of lime concrete. Use of cement here can be reduced by substituting natural slab stone like Shahabad Stone in place of cement concrete. The stone can be laid in cement mortar containing a water repellent and pointed with the same material or with plastic mortar.

USE OF CEMENT IN FLOORS

R.B. or R.C.—construction or R.C. construction with hollow tiles as fillers shall be substituted for solid reinforced concrete construction in intermediate floors except bath and kitchens of buildings provided the bricks and tiles conform to standard specified (in the absence of Indian Standard the British Standard may be referred to) and the concrete in dense and made out of graded aggregate with a low water cement ratio.

In ground floors, the base layer of concrete shall be of lime concrete. Use can be made of polished natural stone in floors in place of terrazo flooring in superior constructions.

USE OF CEMENT IN ROOFS

R.C. joists with hollow clay blocks should be used for roofing flat terraces considered essential for sleeping purposes or for other considerations. Where terraces are not used for any such purpose, use of sloping roofs shall be adopted. Even in areas where the roof is being used for sleeping purposes, sloping roofs shall be combined with flat roofs in the interest of economy in cement.

USE OF CEMENT IN OTHER STRUCTURES

Plastering shall be avoided or where required from aesthetic consideration substituted by lime mortar in the case of inside of stair cases, interior or exterior sides of Barasatis, one side of parapet walls and the exterior faces of all walls not less than $13\frac{1}{2}$ inch thick. It is realised that this involves the use of really first class bricks which are difficult to obtain in sufficient numbers except at a premium in Delhi at present; nevertheless it is considered that enforcement of this specification would result in the manufacture and use of good quality bricks and good quality of workmanship.

Use of cement concrete in pavements and driveways in buildings sites should be avoided altogether.

TABLE VII

MORTARS FOR PLASTERS

Serial No.	Situation	Composition of mortar (proportions by volume)	I.S.I. grading of lime
1	External plaster below damp proof course	1 cement, 1 lime and 6 sand	B or C
2	External plaster above damp proof course	1 cement, 2 lime and 9 sand	B or C
3	Internal plaster on all walls.	(*i*) 1 lime 2 sand	A
		(*ii*) 1 lime, 1 surkhi, 1 sand	B or C
		(*iii*) 1 lime, 1 ash, 1 sand	B or C
		(*iv*) 1 lime 2 surkhi	B or C
		(*v*) 1 lime 2 ash	B or C
		(*vi*) 1 cement, 2 lime and 9 sand	B or C
		(*vii*) 1 cement, 3 lime and 12 sand	

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APPENDIX I

CEMENT PRODUCTION IN INDIA

The total output of cement in India is grossly insufficient: That production of Cement in India has not kept pace with the demand is shown by the following figures:

	1950-51 Tons	1955-56 Tons
(*i*) Demand	—	9,000,000
(*ii*) Annual installed capacity	3,280,000	4,930,000
(*iii*) Actual production	2,692,000	4,280,000

The target figures of installed capacity and production for the year 1960-61 as fixed by the Planning Commission for the Second Five Year Plan are 16 million tons and 13 million tons respectively. The present estimated demand of 9 to 10 million tons is expected to go up to 14 million tons in 1960-61. Acute cement shortage therefore, exists and India's production has to be supplemented by higher priced imports. Even after the target production is realized cement shortage is likely to continue, as it would provide hardly 54 lbs. of cement per head of population.

Comparative figures for 1954 *relating to some other advanced countries*

	Production lbs/capita
Australia	430
Austria	521
Brazil	94
Belgium	1,113
Canada	529
Denmark	622
France	499
Western Germany	736
U.S.S.R.	200
U. K.	536
U.S.A.	630
Turkey	66
India (Target 1960)	54

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APPENDIX II

The following recommendations for reduction factors for different slenderness ratios for masonry walls have been taken from the British Standard Code of Practice C.P. 111(1948). These factors and the associated definitions may be adopted till such time as the Indian Standard Code of Practice for load bearing walls is accepted and published.

Slenderness ratio	Reduction factors	
1	1·0	
2	0·96	
4	0·88	
6	0·80	
8	0·70	
10	0·60	
12	0·50	(Limit for lime mortars.)
14	0·40	
16	0·35	
18	0·30	(Limit for cement mortars.)

The slenderness ratio is obtained by dividing the effective height of the wall or column by its thickness. The effective height is determined as follows:

(i) For columns provided with complete support at bottom and lateral support parallel to the line of one of the horizontal surface dimensions at the top; the effective height relative to the directions of the top support shall be the height between the support.

The effective height at right angles to this shall be twice the height of the column above the lower support.

In the absence of top support the effective height relative to both directions shall be twice its height from the lower support.

(ii) For walls where laterally support at top and bottom, the effective height shall be $\frac{3}{4}$th of the height between such lateral support.

In the absence of top lateral support, the effective height shall be $1\frac{1}{2}$ times the height of the walling above bottom lateral support.

The height between lateral support is termed storey height in many building regulations.

GMGIPD—NS—44NBO—3-9-57—5,000